Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SVC049-01 Room:105 Time:May 23 16:30-16:45

Remote temperature sensing on volcanic fumaroles from hydrogen isotopic compositions of molecular hydrogen in the plume

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Molecular hydrogen (H_2) in a high-temperature volcanic fumarole ($>$ 400 degreeC) reach to the hydrogen isotope exchange equilibrium with coexisting fumarolic H_2O under the outlet temperature of the fumarole. In this study, we applied this hydrogen isotope exchange equilibrium of fumarolic H_2 as a tracer for the remote temperature sensing on volcanic fumaroles, by deducing the hydrogen isotopic composition of fumarolic H_2 remotely from those in volcanic plume. To verify this new remote temperature sensing actually works or not, we determined both concentrations and hydrogen isotopic compositions of H_2 in volcanic plumes emitted from the fumarolic areas showing the outlet temperatures of 630 degreeC (Tarumae), 203 degreeC (Kuju), and 107 degreeC (E-san), and compared the results with those in the fumaroles. The average and the maximum mixing ratio of fumarolic H_2 within the plume H_2 were 97 % and 99 % in Tarumae, 89 % and 96 % in Kuju, 97 % and 99 % in E-san, respectively. In accordance with the enrichment of H_2 in each volcanic plume, we found depletion in the hydrogen isotopic compositions of H_2, showing linear correlation with the reciprocal of H_2 concentration. Besides, the estimated endmember hydrogen isotopic composition for each H_2-enriched component (-260+-30 per mil vs. VSMOW in Tarumae, -509+-23 per mil in Kuju, and -437+-14 per mil in E-san) coincided well with those observed in each fumarole (-247.0+-0.6 per mil in Tarumae, -527.7+-10.1 per mil in Kuju, and -432.1+-2.5 per mil in E-san). Furthermore, the calculated isotopic temperatures in fumaroles almost corresponded with the observed outlet temperature in Tarumae and Kuju, within 20 degreeC difference. We conclude that hydrogen isotopic composition of fumarolic H_2 was quenched within volcanic plume, so that both concentrations and hydrogen isotopic compositions of H_2 in an volcanic plume enable us to deduce those in the fumarole remotely and thus the outlet temperature of fumaroles, at least for those having the outlet temperatures more than 400 degreeC. The remote temperature sensing using hydrogen isotopes (HIReTS) developed in this study can be applicable to obtain more accurate and precise fumarolic temperature in many volcanoes.

Keywords: fumarolic gases, volcanic plume, molecular hydrogen, stable isotopes, isotope exchange equilibrium, remote temperature sensing

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SVC049-02 Room:105 Time:May 23 16:45-17:00

Temporal variations of heat discharge rates from the geothermal area formed during the 2000 eruption of Usu volcano

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We estimate heat discharge rates for a geothermal area formed during the 2000 eruption of Usu volcano, Japan. Airborne surveys and field observations carried out in September 2010 reveal that heat discharge rates from fumaroles, areas of steaming grounds and crater lakes are ˜0, 5.6, and ˜0 MW, respectively. The total heat discharge rate measured in September 2010 represents below 1% of the rate immediately following the eruption.

Integration of the heat-discharge rate from April 2000 to September 2010 yields an accumulated discharge, corresponding to cooling of several percent of the total intruded magma volume estimated from analyses of ground deformation associated with the 2000 eruption. Compared with the 1977 eruption, the 2000 eruption involved the discharge of large amounts of heat from fumaroles. Fumaroles that developed during the 2000 eruption showed a decline in activity in short time. Areas of steaming ground associated with the 2000 eruption showed more rapid growth compared with those of the 1977 eruption but discharged less heat. We suspect that differences in the hydrological environments of the two eruptions (e.g., permeability around the intruded magmas) led to contrasting patterns of propagation of the hydrothermal systems around the intruded magmas.

Keywords: heat discharge rate, Usu volcano, steaming ground, airborne IR survey, hydrothermal system

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SVC049-03 Room:105 Time:May 23 17:00-17:15

Geomagnetic Total Force Observation, Self Potential and VLF-MT Survey around the Oana Crater, Azuma Volcano

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The Oana crater of which the diameter is about 200m is located in the geothermal fumaroles zone at southeast slope of Mt. Issaikyo, Azuma Volcano. In the recent years, a new 300m height fumarole named W-6 appeared inside the crater on November, 2008, and volcanic micro-tremors were observed after an interval of five years in 2010. It seems the volcanic activity of Azuma Volcano has been gradually activated.

In order to monitoring hydrothermal activity beneath the Azuma volcano, a repeat measurement of the geomagnetic total force with 12 observation points has been carried out near the Oana crater since 2003 by the volcanological center of Sendai district meteorological observatory cooperated with Kakioka magnetic observatory. Continuous secular variations in the geomagnetic total force have been observed within a 500m radius area from the center of the crater. Since the variation pattern is increasing at northern and decreasing at southern area of the crater, it suggests that the demagnetization has been progressing beneath the crater. Annual change rate of geomagnetic total force at each observation point is almost constant from started observation year, the maximum change of total intensity amounted to under -20 nT at southern side observation point of the crater. As the demagnetization occurred at geothermal active zone, we think it is a thermal demagnetization caused by hydrothermal activity.

On the other hand, according to the geodetic observation, a pressure source is estimated about 500m under the Oana crater. The pressure source is regarded as a hydrothermal reservoir, and we suppose the pressure of the reservoir depends on a balance of hydrothermal fluid supplements from magma and discharge to the surface. And the depth of pressure source and demagnetization source is almost the same. We suppose the thermal demagnetization is progressing at surrounded area of the reservoir.

Further, we measured self-potential (SP) distribution in 2009 around the Oana crater to detect a SP anomaly caused by hydrothermal convection system. As the results, the observed SP distribution is very flat, so the relation of the SP and the hydrothermal convection system is not clear. We also surveyed surface resistivity structure by VLF-MT method around the SP measured area in 2010. It is found that the resistivity is very low around the Jodo-Daira to the Oana crater.

Keywords: Azuma Volcano, geomagnetic total force, hydrothermal reservoir, thermal demagnetization, self-potential, resistivity

Japan Geoscience Union Meeting 2011
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SVC049-04 Room:105 Time:May 23 17:15-17:30

Approach to evaluating mass flux of volcanic fluids using the electrical conductivity structure of a volcano

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The efficiency of degassing of volcanic fluid in magma is one of the key parameters controlling the explosibility of eruption and the diversity of the volcanic activity (Eichelberger et al., 1986; Kagiyama, 2008). Therefore, it is possible to quantify the constraint condition which controls these phenomena by evaluating the mass flux of volcanic fluids. A portion of released volcanic fluids is discharged from the crater to the atmosphere; the rest is considered to be dissipated by groundwater flow of the aquifer under a volcano. The latter part has not yet been quantified presicely. The electrical conductivity structure of a volcano has a potentiality for estimating the volcanic fluid mass flux by groundwater flow of the aquifer, because the pore water dissolving volcanic fluid has a high electrical conductivity due to the high salinity of the pore water.

So far, the authors have developed the dissipation model of volcanic fluids by assuming the aquifer with simple geometry and physical property, and have examined the quantitative relation between mass flux of volcanic fluids and electrical conductivity structure using the numerical simulations (Komori and Kagiyama, 2008, 2009; Komori et al., 2010). It was found that the attenuation of the conductance of pore water essentially corresponds to the mass flux of volcanic fluids.

In this presentation, the authors attempt to evaluate mass flux of volcanic fluids from the bulk conductivity structure of a volcano obtained from MT survey.

In general, bulk conductivity of a volcano contains both contributions of the pore water and the matrix. The contribution of the matrix to the bulk conductivity affects the pore water conductivity. This means that the contribution of the matrix also affects the evaluation of volcanic fluids mass flux using the bulk conductivity of a volcano. Therefore, it is necessary for evaluating mass flux of volcanic fluids to take the both contributions into account. The quantitative relation between mass flux of volcanic fluids and the spatial distribution of pore water conductivity has been revealed by our previous studies as mentioned above; on the other hand, the spatial distribution of the matrix conductivity has not been revealed yet. In this study, we assumed that the matrix conductivity is a function of temperature and salinity of pore water. The estimated distribution of matrix conductivity is connected to the distribution of pore water conductivity by Revil's model (Revil et al., 1998, 2002) to obtain the distribution of bulk conductivity. The distribution of bulk conductivity is converted into the conductance as a function of the distance of volcanic center. The mass flux of volcanic fluids is estimated by comparing the conductance obtained by MT survey with the catalogs of the conductance vs. the mass flux of volcanic fluids.

These methods are applied to the bulk conductivity of Unzen Volcano obtained by wide-band MT (Komori et al., 2010). In this presentation, some assumptions about the distribution of matrix conductivity are considered. The mass fluxes of volcanic fluids estimated under these assumptions are examined.

Keywords: electrical conductivity structure, bulk conductivity, pore water conductivity, matrix conductivity, mass flux of volcanic fluids

Japan Geoscience Union Meeting 2011
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SVC049-05 Room:105 Time:May 23 17:30-17:45

Conceptual and numerical models of the hydrothermal system at Unzen volcano

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There are three main active geothermal manifestations, that is, Obama hot springs(Natural heat discharge rate Q=50MW), Unzen fumarolic field(Q=21MW) and Shimabara hot springs(Q=0.4MW) from west to east across Unzen volcano, western Kyushu, Japan. A geothermally altered zone is also found on the western flank of the volcano. There are no active geothermal activities at the surface but subsurface temperatures show higher than 240 degree C at a depth of 1000m.

Ohta(1972,1973)presented a comprehensive hydrothermal model based on the discharging of magmatic emanations from the deep magama reservoir beneath Tachibana Bay which is located west of Unzen volcano. The above three geothermal manifestations were generated by transfer of magmatic emanations from west to east and also by differentiation of magmatic emanations. Ohta(2006) presented a modified model later but the essential idea of geothermal fluid flow is the same as the previous model.

Ohsawa(2006) and Fujimitsu et al.(2006) pointed out contribution of lateral flows. Fujimitsu et al.(2006) constructed a numerical model to generate three main geothermal manifestations and a deep high temperature zone with two heat sources beneath the western flank of Unzen volcano. However, it was very difficult to simulate the observed natural heat discharge rates, especially in the Obama hot spring area.

Therefore we constructed new conceptual and numerical models with another heat source beneath Obama hot springs. The presented model well simulated the patterns of geothermal fluid flow and the observed heat discharge rates. The new model with three heat sources beneath the western flank generated all the four geothermal features on Unzen volcano.

Keywords: Unzen volcano, hydrothermal system, conceptual model, numerical model

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SVC049-06 Room:105 Time:May 23 17:45-18:00

Flow of thermal and groundwaters in the Owakidani and Gora area, Hakone

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[1]Hot Springs Research Institute

Oki and Hirano (1970) proposed a synthetic model that combines formation and flow of thermal waters in Hakone caldera with the uprising of volcanic gases, structure of base rocks and thermal conditions. To explain the model simply it is occasionally expressed as ”hot eye and cold eyelid”. The expression describe their idea that cold stratified ground waters are being warmed while they flow from the west around Lake Ashinoko toward the east through the hot region (hot eye) beneath central cones where volcanic gases are rising from magma reservoir existing in the depth. However, having examined in detail data about hydraulic head in the Gora area obtained in the period from 1960 through 2000, Machida et al. (2007) considered that ground waters are rather flowing vertically toward the depth, although the flow has also a component parallel to the inclination direction of the topography. Based on the result, they presented an idea that the zone in the WNW-ESE direction where hot NaCl springs are distributed is not related to the stream of volcanic hot water as considered by the Oki and Hirano model, but represents the extension of the area where reservoir of volcanic hot water rich in NaCl is underplayed,

By having examined concentrations of major anions and their relative concentrations as well as relationships between the oxygen isotope ratio and each concentration of those anions for thermal waters that are flowing out in Gora and Sokokura in detail, we (Kikugawa et at., 2010; Itadera et al., 2010) presented a new model to classify thermal waters in the areas that differs from the Oki and Hirano model. In the new model, existence of $HCO3^-$ in the Zone II springs in the Oki and Hirano model is attributed to the mixing of volcanic gases into the ground water recharged in the site. On the other hand, in the Oki and Hirano model origin of $HCO3^-$ in the Zone II springs was regarded as organic matters buried in the Hayakawa tuff breccia. We consider, as like Machida et al. (2007), that the belt-like zone in the WNW-ESE direction where hot springs rich in NaCl are distributed does not represent route of streams along which volcanic hot waters are diluted by ground waters, for any trend of changes in that direction is observed in temperature, concentration of anions and oxygen isotope ratios. The result by Itadera et al. (2010) that has showed that the uprising of temperature in thermal waters in 1967 in the Gora area occurred first in Sokokura, eastern end of the zone, also strongly supports the above supposition. In the new model, thermal waters in Sokokura is thought to be being formed by the mixing of ground waters and hot springs rich in NaCl that does not flow into the area from the west around Soun hell, but rise up in that site from the depth.

Hot springs that are rich in NaCl are observed only in the Gora area located on the eastern side of central cones. Thermal waters flowing out in base rocks are seen only along Hayakawa and Sukumo rivers that flow toward east. Further, most hot springs are distributed in the eastern half side of the caldera and a tendency of non-overlapping is seen between the spatial distribution of hot springs and hypocenter distribution of swarm earthquakes (Yoshida, 2010). We think all of these characteristics are closely related to the existence of Tanna and Hirayama fault systems that run through in the central part of Hakone caldera in the north-south direction.

Keywords: Hakone volcano, thermal water, groundwater

Japan Geoscience Union Meeting 2011
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SVC049-07 Room:105 Time:May 23 18:00-18:15

Geothermal acvitity dominance in Tatun Volcanic Group, Taiwan

Tsuneomi Kagiyama[1*], Mitsuru Utsugi[1], Chang-Hwa Chen[2]

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Tatun volcanic group (TGV) is located at northern Taiwan. More than 20 volcanic domes and cones have been created around the area bounded by Chinshan Fault in the north and Kanchiao Fault in the south. Most volcanoes have been created before 0.3 M (Wang and Chen, 1990), and no historical record of eruption at TVG. However, eruptions in 18 ka BP (Chen and Lin, 2002) and 6 ka BP (Belousov et al., 2010) have been identified. Yang et al.(1999) found magmatic contribution in fumarolic gas. Kagiyama(2008) proposed that volcanism has a wide range of diversity represented by two typical end members controlled by the easiness of magma storage beneath volcano; 'Eruption dominant (ED) volcanism' in difficult condition and 'Geothermal activity dominant (GD) volcanism' in easier condition. According to the previous paper on VLF-MT, TVG has wide high conductivity area, and this result indicates geothermal activity of TVG might be comparable with that of Beppu geothermal area in Japan. Feature of lava flow indicates viscosity of magma is significantly high than normal viscosity expected by SiO2 content.

These evidences suggest TVG has extruded low temperature magma or degassed magma, and may be consistent with the cause of Geothermal activity dominance.

Keywords: Tatun Volcanic Group, Geothermal activity, Eruption

Japan Geoscience Union Meeting 2011
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SVC049-08 Room:105 Time:May 23 18:15-18:30

DEVELOPMENT OF A NEW SIMPLE HYDROSTATIC EQUILIBRIUM MODEL FOR SUSTAINABLE EVALUATION IN GEOTHERMAL LIMITED RECHARGE

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Geothermal energy is a renewable energy, that is, the energy removed from the geothermal reservoir is continuously replaced on time scales similar to those required for energy removal. Supplied energy to the geothermal reservoir comes from natural recharge and injection. Sustainable production in the geothermal energy development is the ability of the production system applied to sustain the stable production level over long times. It is very important to manage the mass balance between production, injection and natural recharge in the geothermal reservoir during exploitation. A new simple hydrostatic equilibrium model is developed by this mass balance model of geothermal reservoir.

New simple hydrostatic equilibrium model in this paper is built to estimate hydrostatic connection between recharged reservoir and discharged reservoir. Principle of transmission of fluid-pressure in the physical sciences states that pressure exerted anywhere in a confined incompressible fluid is transmitted equally in all directions throughout the fluid such that the pressure ratio remains same. Hydrostatic equilibrium occurs when compression due to gravity is balanced by a pressure gradient force in the opposite direction. Mass changes data in this hydrostatic equilibrium model is estimated by gravity changes from repeat gravity measurement method. The equation result between these parameters estimates recharge factor from discharged reservoir. This model also assumed a relatively constant of entered fluid flow rate from the surface that continues working during the production and injection well activity. This new simple hydrostatic equilibrium model is applied for sustainable evaluation in the geothermal field with limited natural recharge.

Keywords: Hydrostatic equilibrium model, Recharge factor, Geothermal reservoir with limited recharge, Sustainable evaluation

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SVC049-P01 Room:Convention Hall Time:May 23 14:00-16:30

Volatiles and resistivity structure around the aquifer of Mt. Fuji

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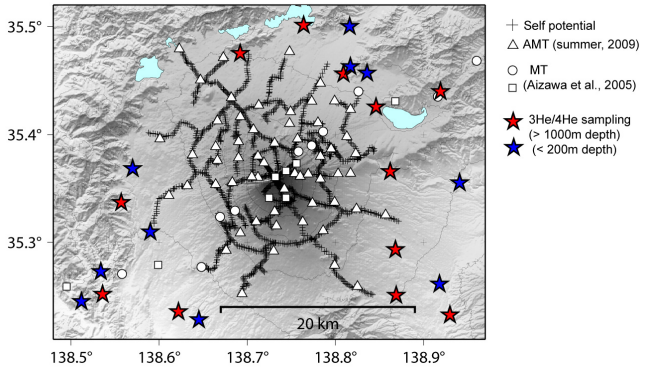
Recently, volatiles in magma are considered to be important for understanding volcanic eruptions, because they may control the occurrence and the style of eruptions. Even in the volcano without active crater or vent, volatile may escapes laterally to the interior of the volcanic body, and therefore, it is useful to investigate the volatile migration path in the volcanic body prior to the eruption. We think that electric resistivity structure may delineate the zone of laterally degassed volatile beneath a volcano. The laterally degassed volatiles are absorbed by groundwater at the shallow level beneath the volcano by dissolution. As a result, the amount of dissolved ions changes, and subsequently changes the groundwater conductive. In summary, the conductive zone in aquifer may indicate the large contribution of volatile. We will investigate the possibility of above scenario with the results of resistivity surveys and 3He/4He ration, D/H and 16O/18O ratios, chemical composition of groundwater at Mt. Fuji volcano. In particular, the relationship between the resistivity structure and the volatile in the deep groundwater (more than 1000m depth) is discussed.



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SVC049-P02 Room:Convention Hall Time:May 23 14:00-16:30

Hot spring waters in basement rocks of Hakone and Yugawara volcanoes

George Kikugawa[1*], Kazuhiro Itadera[1], Akio Yoshida[1]

[1]Hot Springs Research Institute of Kanaga

Hot springs that contain volcanic hot waters or are affected by volcanic gases flow out from ejecta of Hakone volcano in those areas as Owakidani, Ubako, Gora and Ashinoyu located around central cones (e.g., Kikugawa, 2009). Besides these, hot springs originally contained in cracks in Yugashima formations and Hayakawa tuff breccia that compose basement rocks flow out in Hakone-Yumoto, Ohiradai, Miyagino and Dogashima spas distributed along Hayakawa and Sukumogawa rivers. Thermal waters from cracks in basement rocks also flow out in the Yugawara area along Fujikigawa and Chitosegawa rivers, though hot springs of fossil waters that are characterized by very high concentration of NaCl are seen along seashore. In this report features of hot springs in basement rocks of Hakone-Yumoto and Yugawara areas are compared by examining concentrations of main anions, their relative concentrations and oxygen isotope ratios. Then, flow systems of those hot springs are investigated.

One of the features that are common to both of hot springs in base rocks in Hakone-Yumoto and Yugawara is that concentration of HCO_3^- is very low (for almost all of them the concentration is below 100mg/L). Others are the inverse relationship between concentrations of HCO_3^- and $SO4_2^-$, and the positive relationship between concentrations of SO_4^{2-} and Cl^-. However, it should be noted that the relationship between concentrations of SO_4^{2-} and Cl^- is not one, but three types of different correlation coefficients are seen for hot springs in Hakne-Yumoto (Kikugawa and Itadera, 2008). Further, there exists such a group in Yugawara that relationship is not observed apparently between concentrations of SO_4^{2-} and Cl^- due to very low concentration of Cl^-. Weak correlation is observed between concentrations of HCO_3^- and Cl^- for hot springs in Hakone-Yumoto. On the other hand, in Yugawara, in addition to the similar group, there is another type of hot spring in which such a relationship is not recognized because of very low concentration of Cl^-. The latter type corresponds to the group where relationship is not observed between concentrations of SO_4^{2-} and Cl^-.

Although, among number of types of different origin in the Gora area, such hot springs exist that concentrations of SO_4^{2-} and Cl^- are related (Kikugawa et al., 2010; Itadera et al., 2010), there is no such hot springs that posses every feature recognized in hot springs flowing out from cracks in basement rocks. The relationship between the oxygen isotope ratio and the concentration of Cl- seems to be similar to that seen in some types of hot springs in the Gora area. However, relationships between the oxygen isotope ratio and the concentrations of SO_4^{2-} or HCO_3^- differ apparently.

Although hot springs flowing out in Hakone-Yumoto and those in Yugawara show common features as described above, clear differences can be also seen between them. For example, concentration of SO_4^{2-} for most hot springs in Yugawara is notably high compared to that for hot springs in Hakone-Yumoto. Further, as noted by Kikugawa and Itadera (2008), there are several types in hot springs in the area of Hakone-Yumoto for which concentration ratios between main anions are different. In Yugawara as well, it seems that there are multiple types of hot springs as shown above. This is considered to indicate that not one but multiple flow systems exist in each of the areas.

Keywords: hot spring, base rock, Hakone, Yugawara, dissolved constituent

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Fluid geochemistry and trace element composition of a marine hydrothermal circulation system at the Wakamiko crater

Tatsuaki Ohno[1*], Jun-ichiro Ishibashi[1], Shingo Hirao[1], Shogo Oshima[1], Takahito Nishiuchi[2], Takuroh Noguchi[3], Toshiro Yamanaka[2]

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Marine shallow-water hydrothermal activity was located in the Wakamiko submarine crater at 200 m depth in the northern part of Kagoshima Bay, which is considered as the main vent of a gigantic eruption that formed Aira caldera structure. WHV site in the northwest part of the crater was considered as the activity center, where vigorous venting of high-temperature fluid (Tmax = 200 degC) was observed. In SES site located approximately 1 km southeast of WHV site, weak diffusive fluid emanation (T = about 60 degree C) associated with vigorous fumarolic gas discharge was observed. Along the coast of the Kagoshima Bay, that is corresponded to the outer rim of the Aira Caldera, some onland hot springs (T = 43-81 degC) are pumped up from 500-1000m deep.

In this presentation, we will report fluid chemistry of submarine hydrothermal fluids from two sites (WHV site and SES site) in the Wakamiko crater and of onland hot springs, focusing on concentration of trace elements.

[Methods]

Submarine hydrothermal fluid samples were collected during NT10-05 expedition in March of 2010, using ROV *Hyper Dolphin* of JAMSTEC (Japan Agency for Marine Earth Science Technology). Onland hot spring water samples were collected in July of 2010.

We analyzed chemical composition of the fluid samples as follows; ion chromatography and atomic absorption spectrometry for potassium, ICP-AES for sodium, calcium, magnesium, ICP-MS for lithium, rubidium and cesium, AgNO3 titration for chloride.

[Results and discussion]

Both Wakamiko submarine hydrothermal fluids (WHV site and SES site) and onland hot springs have significantly low Na and Cl concentrations with the same Na/Cl ratio as seawater and significantly negative delta D value. These results suggest that both fluids are originated from common reservoir which is contributed from onland ground water and seawater.

It is notable that Ca and K concentrations of the submarine fluid from SES site are lower than those from WHV site. According to the conventional geothermometer assuming equilibrium for water-rock interactions, reservoir temperatures were estimated as 250 degC for WHV site and as 200 deg C for SES site. On the other way, based on temperature records of a platinum resistance thermometer during the fluid-sampling, vent fluid temperatures were estimated as 240 degree C for WHV site and as 180 degree C for SES site, after correction for seawater mixing. This accordance supports the idea that major elements composition of submarine hydrothermal fluids is controlled by hydrothermal interactions within the reservoir at different temperature condition. Fluid temperatures of the onland hot springs in the reservoir are estimated as around 100 degree C.

Li, Rb, and Cs concentrations of three fluids showed highest for WHV site followed by SES site and the onland hot springs. It is known that trace elements are subject to leach from the primary minerals into the fluid and not involved into the secondary minerals during fluid-rock interaction in the reservoir. Positive correlation between the Li, Rb, Cs concentrations and the estimated temperature among these three fluids implies that Li, Rb, Cs concentrations reflect the temperatures of aquifer.

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Geochemical studies of a marine-shallow water hydrothermal system in Kueishantao, Taiwan.

Shogo Oshima[1*], Jun-ichiro Ishibashi[1], Takashi Hagiwara[2], Ayumu Yamada[2], Jing Zhang[2]

[1]School of Science, Kyushu Univ., [2]Faculty of Science, Toyama Univ.

Kueishantao Is. is a volcanic island located about 10-kilometers off NE Taiwan, which is considered as located at the western end of the Ryukyu volcanic arc. The last major eruption of the volcano occurred about 7000 years ago, which formed andesite lava flow and pyroclastics (Chen et al., 2001). More than 30 submarine hydrothermal vents are located at the seafloor of 10 - 30 m water detph along the coast line. Temperature of the vent fluids was as high as 116 oC and the pH is as low as 1.52 (Chen et al., 2005).

With a view to evaluate influence of fluid discharge into the coastal region, we will discuss sources and its contribution to the hydrothermal fluid of Kueishantao. We conducted collaborative studies with National Sun Yat-Sen University in August, 2010. Three fluid samples were collected from hydrtoehrmal vents by scuba diving, and five seawater samples were collected by Niskin bottle from water column above the vent field. Chemical analysis of major elements composition was analyzed by conventional methods using ICP-AES, AAS and IC.

When analytical results are plotted in a two composition diagram, the plots of the obtained samples are aligned along a single line, which is interpreted as a mixing line between two endmemebers. The hydrothermal endmember shows lower concentrations in most species than the other endmeber which is correspond to the ambient seawater. Based on this signature, the hydrothermal component could be attributed as 1) a hydrothermal fluid that experienced water-rock interactions, 2) a vapor phase of the phase separated seawater, or 3) contribution of terrestrial water.

In the case 1), fluid chemistry should reflect results of the water-rock interaction where Mg is removed from the fluid and cations are leached into the fluid. However, the obtained samples showed low concentrations of all the cations including Rb that is a kind of mobile element. In the case 2), concentration ratios among major cation and anion should be close to those of seawater. However, the obtained samples showed rather diverse Na/Cl ratios, which ranges from 0.86 to 0.79. In order to discuss the possibility of the case 3), chemical composition of lake water collected from Lake xxxxx were plotted together for comparison. It is obvious that the plots of the obtained samples in our study are aligned along the mixing line between the lake water and seawater for major cations (Na, K, Mg, Ca). On the other hand, for major anions (Cl, SO4), the obtained samples showed enrichment compared with the mixing line. Strong acidity of the obtained samples suggests involvement of magmatic volatiles into the hydrothermal fluid composition, which well explains also the anion enrichment. We are planning to conduct isotope analyses to obtain more strong evidence.

Chen et al.,(2001)A date for volcanic-eruption inferred from a siltstone xenolith. Quaternary Science Reviews, 20, 869-873.
Chen et al.,(2005)Tide-influenced acidic hydrothermal system offshore NE Taiwan. Chemical Geology, 224, 69-81.

Keywords: shallow water hydrothermal system, Kueishantao

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Audio-frequency Magneto-Telluric survey on Tatun Volcanic group, Taiwan

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Tatun volcanic group (TGV) is located at northern Taiwan. More than 20 volcanic domes and cones have been created within and around Tatun Graben, which is bounded by Chinshan Fault in the north and Kanchiao Fault in the south. Most volcanoes have been created before 0.3 M (Wang and Chen, 1990), and no historical record of eruption at TVG. However, eruptions in 18 ka BP (Chen and Lin, 2002) and 3 ka BP (Chen, unpublished data) have been identified. Yang et al.(1999) found magmatic contribution in fumarolic gas. In our study, we would like to carried out MT (Magneto-Telluric) survey around TVG to clarify subsurface electrical conductivity distribution, which is the sign of degassing around volcanoes.

On TVG area, we made Audio-frequency Magneto-Telluric survey on 5 points. All points are located inside the Yanminshan national park. On this survey, survey line is arranged to cross Seven-star volcano north-west to south-west. The total length of survey line is about 10km. The purpose of this survey is to clarify the geothermal distribution beneath the active area of this volcano. We used three MTU-5A equipments (Phoenix Geophysics Inc.), and made observation during 2-3 hours on each points.

Keywords: Tatun volcanic group

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SVC049-P06 Room:Convention Hall Time:May 23 14:00-16:30

Fluid geochemistry and rock minarals on EGS system

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At EGS system, production fluid geochemistry depends on mineralogy of reservoir rock and circulation system.

During closed-loop circulation test at Habanero EGS site, South Australia, Na, K and Cl concentration were gradually increasing and highwer than those of the previous open flow production test.

In this system, increasing of Na, K may be due to dissolution of feldspars of granite rock at reservoir depth.

Similar trend is shown in production well at Hijiori EGS site, Japan. In Hijiori system, at first 3 month of 2000-2002 long term circulation test, Na,K,Cl were increased and about half concentration of Habanero site. And Ca and SO4 are slightly higher.

This difference is due to the circulation system. At Hijiori, open loop system and injection fluid was supplied from near river water. Then, anhydrite (CaSO4) was dissolved.

On the other hand, at Habanero, closed loop system and no fluid was supplied during circulation. In addition the chemical composition of the granite in which the fluid is circulating is also different, with low-calcium granite at Habanero and high calcium tonalite/granodiorite at Hijiori.

Keywords: geothermal, EGS, fluid chemistry, Rock minerals

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Geothermal Reservoir Monitoring by the Hybrid Repeat Gravity Measurement in Takigami Geothermal Field

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It is important to understand the geothermal reservoir behavior in order to produce geothermal fluid for a long time. And it is required to evaluate the influence of the production and reinjection of a large quantity of geothermal fluid in the geothermal area. The mass changes in the geothermal reservoir with production and reinjection of geothermal fluid cause the gravity changes on the surface. Repeat gravity measurements have been applied at the Takigami geothermal field in Central Kyushu, Japan, where the Takigami power plant (25MW) has been generating since November 1996. We started the repeat gravity measurement in May 1991, before the commencement of power generation at the Takigami geothermal power plant, at 26 observation stations. We used a Scintrex CG-3, CG-3M and CG-5 relative gravimeters in order to measure gravity change caused by production and reinjection of geothermal fluid, but we could not estimate the gravity change at the reference station. To solve this problem, we introduced an A10 absolute gravimeter (Micro-g LaCoste, Inc.). In addition, the A10 was used for not only the assessment of the gravity changes at the reference station, but also the detection of the gravity change caused by the subsurface fluid mass changes at some other measurement stations. However, it was impossible that the A10 absolute gravimeter was applied at all of the stations, because the condition of the measurement was strict. We chose 4 stations (T13B, T22A, T26A and T27A) to conduct the repeat absolute gravity measurement. T26A is located in the reinjection area, and there are the other 3 stations in the production area. Therefore we have applied the relative gravimeters to the stations in such strict situation. Thus both absolute gravimeter and relative gravimeter can complement each other in the hybrid gravity measurement.

We have detected the gravity changes which were consistent with the changes of mass balance in the geothermal reservoir by the relative gravity measurements since 1991. We inferred that the current fluid mass in the Takigami geothermal field has recovered to as much as that before production and reinjection had started. As a result of the absolute gravity measurement, the seasonal variation has not been drastic at the reference station (T1), so we have concluded that T1 is appropriate as the reference station of the relative gravity measurements. In Takigami geothermal power plant, the reinjection was stopped for the regular maintenance. We observed the gravity changes caused by suspension of the reinjection before and after the maintenance period in the reinjection area.

Keywords: Repeat Gravity Measurement, Absolute Gravimeter, Relative Gravimeter, Takigami Geothermal Area

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SVC049-P08 Room:Convention Hall Time:May 23 14:00-16:30

Remote temperature sensing on the fumarolic area in Aso Volcano using hydrogen isotopic compositions of plume H_2

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Molecular hydrogen (H_2) in a high-temperature volcanic fumarole ($>$ 400 degreeC) reach to the hydrogen isotope exchange equilibrium with coexisting fumarolic H_2O under the outlet temperature of the fumarole. In this study, we applied this hydrogen isotope exchange equilibrium of fumarolic H_2 as a tracer for the remote temperature sensing on the fumarolic area in the 1st crater of Mt. Naka-dake (Aso volcano) where direct measurement on fumaroles was not practical, by deducing the hydrogen isotopic composition (dD value) of fumarolic H_2 remotely from those in volcanic plume.

The reciprocal of H_2 concentration in the plume samples showed a good linear relationship with the dD values. The linear relationships suggested that both the concentrations and the dD values of H_2 in the plume samples can be explained by simple mixing between two end-members, both of which can be classified to a single category at least for the dD values of H_2. By extrapolating the linear relationship between $1/H_2$ and dD to $1/H_2$=0 to exclude the contribution of the tropospheric H_2 from the dD value of each sample, we estimated that the dD value of fumarolic H_2 to be -172+-16 per mil vs. VSMOW and the apparent equilibrium temperature (AET_D) to be 868+-97 degreeC. Although the estimated temperatures using the IR thermometers were much lower than the AET_D, we concluded that the AET_D represented the highest outlet temperature of the fumaroles in Aso volcano and that the dimensions of the fumaroles at surface smaller than the pixel of the IR thermometers was responsible for the temperatures lower than the AET_D. That is to say, temporal variation in the dimensions of fumaroles at surface, probably due to variation in the emission flux of fumarolic gases, was responsible for the temporal variation in the temperature determined by the IR thermometers, while the actual outlet temperature of the Aso fumaroles keeps the temperature almost equal to the equilibrium temperature of fumarolic gases.

Keywords: fumarolic gases, volcanic plume, molecular hydrogen, stable isotopes, isotope exchange equilibrium, remote temperature sensing

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SVC049-P09 Room:Convention Hall Time:May 23 14:00-16:30

Remote sensing of the temperature and the amount of water of volcanic fumarole gas using lidar technique

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Temperature and water vapor (including waterdrops) measurements of volcanic fumarole gas is important to know the activity of volcanoes and to predict eruptions. However, volcanic fumarole gas is usually poisonous and quite high temperature. So, getting too close to the volcanic fumarole for a gas sampling and direct measurement of temperature are extremely dangerous. We, therefore, are developing two lidars for remote sensing; one is a portable Raman lidar for measuring of water vapor and waterdrops in volcanic fumarole and the other is a portable bistatic lidar for temperature measurements of volcanic fumarole gas. In this presentation, we introduce the developing lidars and report results of observation test of fumarole gas that was carried out at Bandaiko (Kusatsu) in October, 2010.

Keywords: water vapor, temperature, volcanic fumarole gas, remote sensing, Lidar

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SVC049-P10 Room:Convention Hall Time:May 23 14:00-16:30

Relationship between the coefficient of geothermal flux for the heat balance technique and micrometeorological data

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The coefficient of geothermal flux is essential for the heat balance technique (Sekioka and Yuhara, 1974), which is one of the methods for measurement of heat discharge rate from geothermal fields, and is determined by micrometeorological data of a target area. In order to comprehend the temporal change of the micrometeorological conditions and the coefficient of geothermal flux, we have manufactured an automated continuous micrometeorological measurement system and measured micrometeorological data at the Kyu-Hachiman-Jigoku geothermal unit in the Unzen geothermal area in Nagasaki Prefecture, the Komatsu-Jigoku geothermal unit in Oita Prefecture, Aso Volcano in Kumamoto Prefecture and Hakozaki Campus in Fukuoka Prefecture. As a result, the values of the coefficient of geothermal flux showed turbulent changes in a wide range and in a short time (Fujimitsu et al., 2009).

We conducted the continuous micrometeorological measurements in Aso in 2005 and in Komatsu-Jigoku in 2005 and 2006 with 1-minute, 10-minute and 5-second intervals, respectively. And we obtained 5596, 534 and 4621 sets of the observed micrometeorological data and the coefficient of geothermal flux values calculated by using the observed data, which were applicable for the statistical processing. The correlation coefficients (multiple correlation: R) between the 8 micrometeorological conditions (atmospheric temperatures at 10, 50, 55, 150 cm heights, relative humidity values at 10, 50, 150 cm heights and a wind velocity at 100 cm height) and the values of the coefficient of geothermal flux did not show very strong correlations (the maximum R is 0.45 with the atmospheric temperature at 55 cm height at Komatsu-Jigoku in 2005). The values of R between the 4 parameters (the vapor pressure, the density of the air, the transfer velocity, the reciprocal of the Bowen ratio) calculated by using the observed micrometeorological data and the values of the coefficient of geothermal flux indicated a weak negative correlation with the density of the air and no obvious correlation with the vapor pressure. And although the values of R with the transfer velocity and the reciprocal of the Bowen ratio showed some positive correlations but large variations, the values of R with the product of the transfer velocity and the reciprocal of the Bowen ratio indicated extremely strong positive correlations (R=0.97 to 0.99) in every case. Therefore, we obtained a regression equation for the relation between the coefficient of geothermal flux and the product of the transfer velocity and the reciprocal of the Bowen ratio. It means that we can estimate the value of the coefficient of geothermal flux with simpler process than before.

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Keywords: Heat balance technique, coefficient of geothermal flux, micrometeorology, continuous measurement, heat discharge rate